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Ottawa Hull K1A 0C9

(21) (A1) 2,120,454
(22) 1994/03/31
(43) 1995/10/01

(51) INTL.CL.[5] B61C-017/12

(19) (CA) **APPLICATION FOR CANADIAN PATENT** (12)

(54) Remote Control System for a Locomotive

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(57) 3 Claims

Notice: This application is as filed and may therefore contain an incomplete specification.

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ABSTRACT OF THE DISCLOSURE

A locomotive control system comprising a remote transmitter issuing binary coded commands and a slave controller mounted on the locomotive that decodes the transmission and operates various actuators to carry into effect the commands remotely issued by the operator.

FIELD OF THE INVENTION

The present invention relates to an electronic system for remotely controlling a locomotive.

DESCRIPTION OF THE DRAWINGS

A preferred embodiment of the invention will be described with preference to the annexed drawings, in which:

- Figure 1 is a top plan view of the portable transmitter of the remote control system in accordance with the invention;

- Figure 2 is a side elevational views of the remote transmitter;

- Figure 3 is a front elevational view of the remote transmitter;

- Figure 4 is a block diagram of the remote transmitter;

- Figure 5 is a diagram illustrating the signal transmission protocol;

- Figure 6 is a block diagram of the slave controller mounted onboard the locomotive;

- Figure 7 is a graph illustrating the relationship between the signal transmission and the signal reception;

- Figure 8 is a graph illustrating the relationship signal transmission/reception where two remote controllers operate simultaneously;

- Figure 9 is a detailed block diagram of the slave controller mounted onboard the locomotive;

- Figure 10 is a side elevational view of a timing disk for generating a pulse signal whose frequence is correlated to the speed of the locomotive;

- Figure 11 is a side elevational view of the timing disk shown in Figure 10;

- Figure 12 illustrates the pulse output of the velocity measurement system shown in Figures 10 and 11;

- Figures 13a and 13b are a block diagram illustrating the logic to control the speed of the locomotive;

- Figure 14a is a block diagram illustrating the logic to control the speed of the locomotive in the coast setting;

- Figure 14b is a flow chart illustrating the logic to control the speed in coast with brake setting;

- Figure 15 is a flow chart of the logic enforced to transfer the command authority from one remote control transmitter to another; and

- Figure 16 is a flow chart of the safety checks performed on the braking system.

With reference to the annexed drawings, the locomotive control system in accordance with the invention includes a portable transmitter 10 which generates a digitally encoded radio frequency (RF) signal to convey commands to a slave controller mounted on-board the locomotive. The slave controller decodes the transmission and operates various actuators on the locomotive to carry into effect the commands remotely issued by the operator.

Figures 1 to 3 illustrate the physical layout of the portable transmitter 10. The unit comprises a housing 12 enclosing the electronic circuitry and a battery supplying electric power to operate the system. A plurality of

manually operable levers and switches projecting outside the housing 12 are provided to dial-in locomotive speed, brake and horn settings, among others. The various controls on the portable transmitter are defined in the following table:

REFERENCE NUMERAL	FUNCTION	TYPE OF ACTUATOR
14	Locomotive Speed Control	Multi-Position Lever
16	Locomotive Override Brake Control	Multi-Position Lever
18	Reset	Push-Button
20	Direction (Forward/Reverse/ Neutral)	Multi-Position Switch
22	Ring Bell/Horn	Toggle Switch
24	Train Brake Control	Toggle Switch
26	Power on/Lights Dim/Bright	Multi-Position Switch
28	Status Request	Push-Button
30	Time Extend	Push-Button
32	Relinquish Control to Companion Portable Transmitter	Push-Button

A detailed description of the various functions summarized in the above table is provided later in this specification.

On the top surface of the housing 12 is provided a display panel 34 that visually echoes the control settings of the portable transmitter 10. The display panel 34 includes an array of individual light sources 36, such as

light emitting diodes (LED), corresponding to the various operative conditions of the locomotive that can be selected by the operator. Hence, a simple visual observation of the active LED's 36 allows the operator to determine the current position of the controls.

Figure 4 provides a functional diagram of the portable transmitter 10. The various manually operable switches and levers briefly described above are constituted by electric contacts whose state of conduction is altered when the control settings are changed. For instance, the push-buttons 18, 28, 30 and 32, and the toggle switches 22 and 24 have electric contacts that can assume either one of a closed condition and the opened condition. The multi-position levers 14 and 16, and the multi-position switches 20 and 26 have a have a set of electric contact pairs, only a single pair being closed at each position of the lever or switch. By reading the conduction state of the individual electric contact pairs the commands issued by the operator can be determined.

An encoder 38 scans at short intervals the state of conduction of each pair of contacts. The scan results allows the encoder to assemble a binary locomotive status word that represents the requested operative state of the locomotive being controlled. The following table provides

the number of bits in the locomotive status word required for each function:

NUMBER OF BITS IN LOCOMOTIVE STATUS WORD	FUNCTION
3	Locomotive Speed Control
3	Locomotive Brake Control
1	Reset
2	Direction (Forward/Reverse/ Neutral)
2	Ring Bell/Horn
3	Train Brake Control
1	Lights Dim/Bright
1	Status Request
1	Time Extend
1	Relinquish Control to Companion Portable Transmitter

The locomotive status word also contains a binary locomotive identifier segment that uniquely represents the locomotive associated with the portable transmitter. The purpose of this feature is to ensure that the locomotive will only accept the commands issued by the transmitter generating the proper identifier.

Most preferably, the encoder 38 included a microprocessor programmed to intelligently assemble the locomotive status word. The microprocessor continuously

scans the electric contacts of the transmitter controls and records their state of conduction. On the basis of the identity of the closed contacts the program will produce the function component of the locomotive status word which is the string of bits that uniquely represents the functions to be performed by the locomotive. The program then appends to the function component the locomotive identifier component and preferably a data security code enabling the receiver on-board the locomotive to check for transmission errors.

In a different form of construction, the encoder may be constituted by an array of hardwired logic gates that generate the locomotive status word upon actuation of the controls.

A transmitter 40 receives the locomotive status word and generates an RF signal for transmission of the coded sequence by frequency shift keying. In essence, the frequency of a carrier is shifted to a first value to signal a logical 1 and to a second value to signal a logical 0. The transmission scheme is best shown in Figure 5. Each transmission begins with a burst of the carrier frequency 42 for a duration of eight (8) bits (the actual time frame is established on the basis of the transmission baud rate in terms of bits per second allowed by the equipment). Each bit of the data stream is then

sent by shifting the frequency to the first or the second value in dependence of the value of the bit, during a predetermined time slot 44. Each time slot has a duration of 80 bits times the selected baud/rate.

The transmitter 40 sends out the locomotive status word in repetition at a fixed rate selected in the range of two (2) to five (5) times per second. By providing the transmitter with a unique reptition rate the likelyhood of transmission errors is reduced when several portable transmitters in close porximity broadcast control signals to individual locomotives, as described below.

Figure 6 provides a diagrammatic representation of the slave controller mounted on board the locomotive. The slave controller identified comprehensively by the reference numeral 46 has three main components, namely a receiver unit 48, a processing unit 50 and a driver unit 52. More particularly, the receiver unit 48 senses the locomotive status word send out from the portable transmitter 10, decodes the transmission and supplies the resulting binary sequence to the processing unit 50. To achieve a reliable communication link the receiver 48 is synchronized with the transmitter 40 at three different levels. First the receiver circuitry defines a signal acceptance window that opens itself at the rate at which the locomotive status word is send out by the respective

controlling transmitter 40. Second, the receiver 40 will observe the frequency value of the transmission in order to decode the binary sequence at intervals precisely corresponding to the time slots 44. Third, the acceptance window opens in phase with the signal transmission.

The first two levels of synchronization are established through hardware design, by setting the transmitter 40 and the receiver 48 to the same period of transmission/reception. On the other hand, the phasing of the receiver to the incoming locomotive status word transmission is effected through observation of the burst of carrier frequency 42 that begins each transmission cycle. The diagram in Figure 7 graphically illustrates the relationship between the signal transmission and the signal reception. The time line 54 shows the successive transmission of the locomotive status word as a series of blocks 56. The activity of the receiver 48 is shown on the time line 58. The hatched areas correspond to the time intervals during which the receiver is not listening. At time t=0 the first locomotive status word is send out by the transmitter 40. The burst 42 of the carrier frequency is sensed by the receiver 48 which then activates the sequence of opening and closing of the signal acceptance window which is fully synchronized (in period and phase) with the signal transmission.

This characteristic is particularly advantageous when several transmitters broadcast simultaneously control signals to different locomotives in close proximity to one another. By setting each transmitter (and the companion receiver) at a unique transmission/reception period secure communication links can be maintained even when all the transmitters use the same carrier frequency. Figure 8 illustrates this feature. Time line 60 shows the transmission pattern of a first portable transmitter. The time line 62 depicts the window of acceptance of the companion receiver. The numeral 64 identifies the transmission pattern of a second portable transmitter. Assuming that both portable transmitters are actuated exactly at t=0, the signal received during the first opening of the window of acceptance will be corrupted since two locomotive status words transmissions are concurrent in time. However, the third and the seventh locomotive status word transmissions from the first portable transmitter will be clearly received since there is no overlap with the locomotive status words sent out by the second portable transmitter.

The transmitter/receiver gear of the remote locomotive control system has been described above in terms of function of the principal parts of the system and their interaction. The components and interconnections of the electric network necessary to carry into effect the

desired functions are not being specified because such details are well within the reach of a man skilled in the art.

Figure 9 provides a functional diagram of the processing unit 50. A central processing unit (CPU) 66 communicates with a memory through a bus 70. A reserved portion memory 68 contains the programm that directs the CPU 66 to control the locomotive in dependence of the several inputs that will be discussed later. The memory also contains a section allowing temporary storage of data used by the CPU when handling hardware events.

The current locomotive status and the commands issued from the remote transmitter are directed to the CPU through an interface 72 communicating with the bus 70. The interface 72 receives input signals from the following sources:

a) A speed direction sensor 74 providing locomotive velocity and direction of movement data;

b) A speed sensor 76 providing solely locomotive velocity data. The speed sensor 76 is provides the CPU 66 with redundant velocity data

allowing the CPU 66 to detect a possible failure of the main speed sensor 74.

c) A pressure sensor 78 observing the air pressure in the locomotive brake system;

d) A pressure sensor 79 observing the air pressure in the main reservoir;

e) A pressure sensor 80 observing the air pressure in the train brake system;

f) A sensor 82 observing the flow rate of air in the brake system of the train; and

g) The decoded locomotive status word generated by the receiver 48.

The structure of the speed/direction sensor 74 is illustrated in Figures 10 and 11. The sensor includes a disk 84 mounted to an axle 86 of the locomotive. When the locomotive is moving the disk 84 turns at the same angular speed as the axle 86. The disk 84 is provided with a layer of reflective coating 85 deposited to form on the periphery of the disk equidistant and alternating reflective zones 87 and substantially non-reflective zones 89. A pair of opto-electric sensors 92 and 94 are

mounted in a spaced apart relationship adjacent the periphery of the disk 84. The sensor 92 comprises an emitter 92a generating a light beam perpendicular to the plane of the disk 84, and a receiver 92b producing an electric signal when sensing the reflection of the light beam on the reflective zones 87. However, when a substantially non-reflective surface 89 registers with the sensor 92, the output of the receiver is null or very low. The structure and operation of the opto-electric sensor 94 is identical to the sensor 92.

The spacing between the opto-electric sensors 92 and 94 is such that they generate output pulses due to the periodic change in reflectivity of the disk surface, occuring at different instants in time. As best shown in Figure 10, and assuming that the disk 84 rotates in the counter clockwise direction, when the sensor 92 switches on as a result of a reflective zone 87 registering with the emitter 92a and the receiver 92b, the sensor 94 is still in a stable on condition and can be caused to switch off only by further rotating the disk 84.

Preferably, the disk 84 and the sensors 92 and 94 are mounted in a hermetically sealed housing to protect the assembly against contamination by water or dirt.

Figure 12 illustrates the signal waveforms produced by the opto-electric sensors 92 and 94. Both outputs are pulse trains having the same frequency but out of phase by an angle α which depends upon the spacing of the sensors 92 and 94. When the locomotive moves forward the disk 84 rotates in a given direction, say clockwise. In this case, the pulse train from sensor 94 leads the pulse train from sensor 92 by angle α. When the locomotive is in reverse, then the output of sensor 92 leads the output of sensor 94 by angle α (this possibility is not shown in Figure 12). The processing unit 50 observes the occurrence of the leading pulse edges from the sensors 92 and 94 with relation to time to determine the identity of the leading signal, which allows to derive the direction of movement of the locomotive.

Velocity data is derived by measuring the rate of fluctuation of the signal from any one of sensors 92 and 94. It has been found practical to determine the velocity at low locomotive speeds by measuring the period of the signal. However, at higher speeds the frequency of the signal is being measured since the period shortens which may introduce non-negligeable measurment errors.

The speed sensor 76 is similar to sensor 74 described above with two exceptions. First, a single opto-electric sensor may used since all that is required is velocity

data. Second, the speed sensor 76 is mounted to a different axle of the locomotive.

The pressure sensors 78 and 79 are switches mounted to the main reservoir and to the pneumatic line that supplies working fluid to the locomotive independent braking mechanism, and produce an electric signal in response to pressure. These sensors merely indicate the presence of pressure, not its magnitude. In essence, each sensor produces an output when the air pressure exceeds a preset level, indicating whether the reserve of compressed air is sufficient for reliable braking. Unlike the sensors 78 and 79, the pressure sensor 80 is a transducer that generates a signal indicative of presence and magnitude of pressure in the train brake air line.

The airflow sensor 82 observes the volume of air circulating in the pneumatic lines of the train brake system. The results of this measurement along with the output of pressure sensor 78 provide an indication of the state of charge of the pneumatic network. It is considered normal for a long pneumatic path to experience some air leaks due primarily to imperfect unions in pipe couplings between cars of the train. However, when a considerable volume of air leaks, the airflow sensor 82 enables the processing unit to sense such condition and to implement corrective measures, as will be discussed later.

The interface 72 receives the signals produced by the sensors 74, 76, 78, 79, 80, and 82 digitizes them where required so they can be directly processed by the CPU 66. The locomotive status word issued by the receiver 48 requires no conversion since it is already in the proper binary format.

The binary signals generated by the CPU 66 that control the various functions of the locomotive are supplied through the bus 70 and the interface 72. The following control signals are being issued:

a) A signal 98 to set the lights of the locomotive to off/low intensity/high intensity. The signal is constituted by one (1) bit, each operative condition of the locomotive lights being represented by a different bit state;

b) A two (2) bit signal 100 to operate the bell or the horn of the locomotive;

c) A five (5) bit signal 102 for traction control. Four bits are used to communicate the throttle settings (only eight (8) settings are possible) and one bit for the power contacts of the electric traction motors;

d) An eight (8) bit signal 104 for train brake control. The number of bits used allows 256 possible brake settings; and

e) A seven (7) bit signal 106 for independent brake control. The number of bits used allows 128 possible brake settings.

The interface 72 will convert at least some of the signals 98 to 108 from the binary form to a different form that the devices at which the signals are directed can handle. This is described in more detail below.

The actuators for the lights and bell/horn are merely switches such as relays or solid state devices that energize or de-energize the desired circuit. The interface 72, in response to the CPU 66 instruction to set the lights/bell/horn in the desired operative position will generate an electric signal that is amplified by the driver unit 52 and then directed to the respective relay or solid state switch.

With regard to the traction control it should be noted that most locomotive manufacturers will install on the diesel/electric engine as original equipment a series of actuators that control the fuel injection, power contacts and brakes among others, hence the tractive power

that the locomotive develops. This feature enables to couple several locomotives under control of one driver. By electrically and pneumatically interconnecting the actuators of all the locomotives, the throttle commands the driver issues in the cab of the mother engine are duplicated in all the slave locomotives. The locomotive remote control system in accordance with the invention makes use of the existing throttle/brake actuators in order to control power. The interface 72 converts the binary throttle settings issued by the CPU 66 to the standard signal protocol established by the industry for controlling a throttle/brake actuators. This feature is particularly advantageous because the locomotive remote control system does not require the installation of any throttle/brake actuators. As in the case of the lights and bell/horn signals 98 and 100, respectively, the traction control signal incoming from the interface 72 is amplified in the driver unit 52 before being directed to the throttle/brake actuators.

The train brake control signal 104 issued by the interface 72 is an eight (8) bit binary sequence applied to a valve mounted in the train brake circuit to modulate the air pressure in the train line that controls the braking mechanism. The working fluid is supplied from a main reservoir whose integrity is monitored by the pressure sensor 79 described above. The independent

locomotive brake is controlled in the same fashion with binary signal 106.

The operation of the locomotive control system will now be described with more detail.

SPEED CONTROL TASK

The flowchart of the speed control logic is shown in Figures 13a to 13d. The program execution begins by reading the velocity data generated from sensors 74 and 76 that are mounted at different axles of the locomotive. The data gathered form each sensor is stored in the memory 68 and then compared at step 124. If both sensors are functioning properly they should generate identical or nearly identical velocity values. In the event a significant difference is noted the CPU 66 concludes that a malfunction exists and issues a command (step 126) to fully apply the independent brake in order to bring the locomotive to a complete stop.

Assuming that no mismatch between the readings of sensors 74 and 76 is detected, the CPU 66 will compare the observed locomotive speed with the speed requested by the operator. The later variable is represented by a string of three (3) bits in the locomotive status word (the flowchart of Figures 13a to 13d assumes that the

locomotive status word has been correctly received and is stored in the memory 68). The operator can select on the portable transmitter 10 eight possible speed settings, each setting being represented by a different binary sequence. The speed settings are as follows:

1) STOP
2) COAST WITH BRAKE
3) COAST
4) COUPLE (1 MILE PER HOUR (MPH)
5) 4 MPH
6) 7 MPH
7) 10 MPH
8) 15 MPH

If any one of settings 4 to 8 have been selected, which require the locomotive to positively maintain a certain speed, the CPU 66 will effect a certain number of comparisons at steps 128 and 130 to determine if there is a variation between the actual speed and the selected speed along with the sign of the variation, i.e. whether the locomotive is overspeeding or moving too slowly. More particularly, if at step 128 the CPU 66 determines that the observed speed is in line with the desired speed no corrective measure is taken and the program execution initiates a new cycle. On the other hand, if the actual speed differs from the setting, the conditional test 130

is applied to determine the sign of the difference. Under a negative sign, i.e. the locomotive is moving too slowly, the program execution branches to processing thread A (shown in Figure 13b). In this program segment the CPU 66 will determine at step 132 the exact difference between the setting and the actual speed and then calculate a new throttle setting to compensate the error. A proportional plus derivative plus integral algorithm is used for this purpose where the new throttle setting is a linear combination of the error signal its derivative and its integral. The new throttle setting is then applied as signal 102 (see Figure 9) to the throttle actuator of the locomotive to control the power output.

When the new throttle setting has been implemented the program execution continues to steps 134 and 136 where the current direction of movement and speed of the locomotive is determined from the reading of sensor 74. In the event the CPU 66 observes a zero speed value for a time period of more than 20 seconds in spite of the fact that a tractive effort is being applied (step 138), it declares a malfunction and fully applies the independent locomotive brake. Normally, when a tractive effort is applied it causes the locomotive to accelerate. The movement, however, may occur after a certain delay following the application of the tractive effort especially if the locomotive is pulling a heavy consist.

Still, if after a certain time period no movement is observed, some sort of malfunction is probably present. One possibility is that both sensors 74 and 76 have failed and register zero speed even when the locomotive is rolling. This is highly unlikely but not impossible. When such condition is encountered the CPU 66 immobilizes the locomotive immediately upon determination that a fault is present.

The 20 seconds waiting period before application of the independent brake is implemented by verifying the velocity data from sensor 74 during a certain number of program execution cycles. For instance, the current velocity value is compared to the velocity value observed during the previous execution cycle that has been stored in the memory 68. If a change is noted, i.e. the locomotive moves, then the step 138 is considered to have been successively passed. If, however after a predetermined number of program execution cycles, 200 that require about 20 seconds to be completed no change with the previously observed velocity value is noted, the independent brake is fully applied.

Assuming that motion of the locomotive is detected at step 138, the program precedes to step 140 where the direction of movement of the locomotive read from the output of sensor 74 is compared to the direction of

movement specified by the operator. This value is represented by a four (4) bit string in the locomotive status word. If the locomotive is moving rearwardly while the operator has specified a forward movement, the CPU 66 detects a condition known as "rollback". Such condition may occur when the locomotive is starting to move upwardly on a grade while pulling a heavy consist. Under the effect of gravity the train may move backward for a certain distance until the traction system of the locomotive has been able to build-up the pulling force necessary to reverse the movement. During a rollback condition the electric current in the traction motors of the locomotive increase beyond safe levels. Hence it is desirable to limit the rollback in order to avoid damaging the hardware. The program is designed to tolerate a rollback condition for no longer than 20 seconds. If the condition persists beyond this time period the independent brake is fully applied. The 20 seconds delay is implemented by comparing the evolution of the results of the comparison step 140 with the results obtained during the previous execution cycle; if the results do not change for a certain number of program execution cycles that require about 20 seconds of running time on the CPU 66, 200 a fault is declared and the brake applied.

In the case where both tests 136 and 140 are successively passed, i.e. the locomotive is moving in the

selected direction, the program execution returns to the beginning of the cycle as shown in Figure 13a.

Referring back to step 130, if the conditional branch points toward processing thread B (see Figures 13a and 13c), which means that the locomotive is overspeeding, then the CPU 66 will calculate at step 142 the difference between the selected speed and the observed speed. The resulting error signal is then processed by using a proportional plus derivative plus integral algorithm to derive a new throttle setting and a new brake setting. Unlike processing thread A (followed when the locomotive moves too slowly) that uses the throttle as a single control lever, processing thread B uses brake modulation an additional control lever. The calculated throttle and brake settings are issued as binary signals 102 and 106 (see Figure 9) that are directed to the respective actuators on the locomotive.

The STOP, COAST WITH BRAKE and COAST settings will now be briefly described. The STOP setting as the name implies intends to bring and maintain the locomotive stationary. When the CPU 66 receives a locomotive status word containing a speed setting corresponding to STOP it immediately terminates the tractive effort and applies the independent locomotive brake at a controlled rate.

The program logic to implement the COAST and COAST WITH BRAKE services is illustrated as flowcharts in Figure 14a and 14b, respectively. When the multi-position lever 14 is set to the COAST setting the program reads the velocity data from sensor 74 at step 144 and then compares it at step 146 to the velocity value recorded during the previous program execution cycle. If the consist accelerates under the effect of gravity down a grade (no tractive effort is applied by the system in the COAST and COAST WITH BRAKE settings) the observed velocity will show an increase. The CPU 66 will then apply the independent locomotive brake to slow the consist. In the event that no velocity increase is observed the CPU 66 will set the independent brake to the release position at step 150 or keep the brake at the current setting. Note that step 150 does not necessarily imply a change of brake setting. If during the previous program execution cycles no brake application was required, the CPU 66 will only maintain the release setting during the current cycle. However, if the brakes were previously applied and step 146 confirms that the consist has been slowed down sufficiently, then the brakes can be actuated toward the release position depending upon the pid algorith output.

The next step in the program execution is a test 152 which determines if the speed of the consist is below 0.5 MPH. In the affirmative the movement is stopped by full

application of the independent brake at step 154. If the speed of the consist exceeds or is equal to 0.5 MPH then the program returns to step 144.

The COAST WITH BRAKE function, depicted in Figure 14b is very similar to the COAST service described above. The only difference is that a minimum independent brake pressure of 15 pounds per square inch (psi) is always maintained. At step 156 the acceleration of the consist is determined by comparison of the current velocity with a previous velocity value. If a positive acceleration is observed, such as when the consist moves down a grade, the brake pressure is increased at step 158. During the next program execution cycle the acceleration is determined again. If no positive acceleration is sensed the brake pressure is returned to 15 psi at step 160. At step 162 the velocity of the consist is tested against the 0.5 MPH value. If the current speed is less than this limit a full independent brake application is effected in order to stop the consist, otherwise the program execution initiates a new cycle.

EXCHANGE OF COMMAND AUTHORITY BETWEEN REMOTE TRANSMITTERS

In some instances a single operator may effectively and safely control a consist that includes a limited number of cars remaining at all times well within the visual range of the operator. However, when the consist

is long two operators may be required, each person being physically close and monitoring one end of the train. The present invention provides a locomotive control system capable of receiving inputs from the selected one of two or more remote transmitters. In a two-operator arrangement, each person is provided with a portable transmitter 10 capable to generate the complete range of locomotive control commands. In order to avoid confusion, however, the slave controller on-board the locomotive will accept at any point in time commands from a single designated transmitter. The only exception is a limited set of emergency and signalling commands that are available to both operators. The control function can be transferred from one transmitter to the other by following the logic depicted in the flowchart of Figure 16.

Upon reception of a locomotive status word, the CPU will compare the identifier in the word to a list of two or more possible identifiers stored in the memory 68. The list of acceptable identifiers should contain the identifiers of all the remote transmitter susceptible to receive the control functions of the locomotive. If the identifier in the locomotive status word does not correspond to any one of predetermined identifiers in memory, then the system rejects the word and takes no action. Otherwise, the system will determine what are the requested commands that locomotive should effect. If the

locomotive status word requests emergency brake application or to sound the bell or horn, then the system complies with the request. Otherwise (step 179) if a new speed setting is requested for example, the system will comply only if the identifier matches with the identifier of the remote controller that is the designated one to issue commands. If this step is verified, then the locomotive executes the command unless the command is a request to transfer command authority to another remote controller. If this is so, the program execution continues at step 180 where the CPU 66 will perform a certain number of safety checks to determine if the command transfer can be made in a safe manner. More particularly, the CPU will determine if the locomotive is stopped and if the brake safety checks (to be described later) are verified. If the locomotive is moving or the brake safety check fail, then no action is taken and the command remains with the portable transmitter currently in control. If this test is passed, then the CPU will monitor the locomotive status words broadcasted from the remote transmitters having an identifier in the list stored in the memory 68. If within 10 seconds of the reception of the request to transfer control from the current transmitter the CPU observes that any of the other locomotive status words contains a reset bit in the high position, i.e. which means that the operator of that remote control has depressed the reset button, then it

changes in memory the address of the currently active identifier to replace the current identifier by the one corresponding to the transmitter whose reset botton has been depressed. The above procedure is used for safety purposes in order to transfer the control of the locomotive only when the target remote controller has effectively acknowledge acceptance of the command.

If within the 10 seconds no reset bit is set to the high position, the CPU 66 will abort the transfer function and resume normal execution of the program.

BRAKE SAFETY CHECKS

Figure 16 is a flow chart of a program segment used to identify the state of readiness of the braking system before authorizing movement of the locomotive. When a command to move forward the locomotive is received, the CPU 66 will check the pressure in the main tank that supplies compressed air to both the independent locomotive and the train brake locomotive. If the pressure is below a preset level, the command to move the locomotive forward is aborted and no action is taken. A second verification step required to allow movement of a locomotive is a flow rate of compressed air in the train brake line below a preset level. As briefly discussed earlier, it is normal for a train brake line to exhibit a certain leakage due to

imperfect couplings in unions between cars. However, when this leakage exceeds a predetermined level which means that either there is a major leak or the system is totally discharged and it is currently being pumped with air.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A locomotive remote control system comprising:

- a transmitter capable to generate a binary coaded radio frequency signal representing commands to be executed by the locomotive;

- a slave controller for mounting onboard the locomotive, said slave controller comprising:

a) a receiver for sensing said radio frequency signal;

b) a processor for receiving said radio frequency signal;

c) a velocity sensor means for generating data representing velocity of the locomotive, said processor being responsive to said velocity sensor means and to said RF signal to actuate either one of a brake of a locomotive or attractive power of the locomotive in order to attempt maintaining a requested speed.

2. A locomotive control system comprising:

a) a transmitter for generating a binary coaded RF signal; and

b) a slave controller mounted onboard the locomotive for receiving said signal, said slave controller

constituting means for selectively accepting commands from a first transmitter or from a second transmitter.

3. A remote control system for a locomotive comprising:

a) a transmitter for generating an RF binary coaded signal; and

b) a slave controller mounted onboard the locomotive, said slave controller comprising:

- a first sensor responsive to pressure of compressed air in a main tank of said locomotive;

- a second sensor responsive to flow of compressed air in a pneumatic brake line, said slave controller being responsive to output of said sensors to enable said locomotive to move only when a pressure in said main tank is above a predetermined level and a flow of air in said brake line is below a predetermined level.

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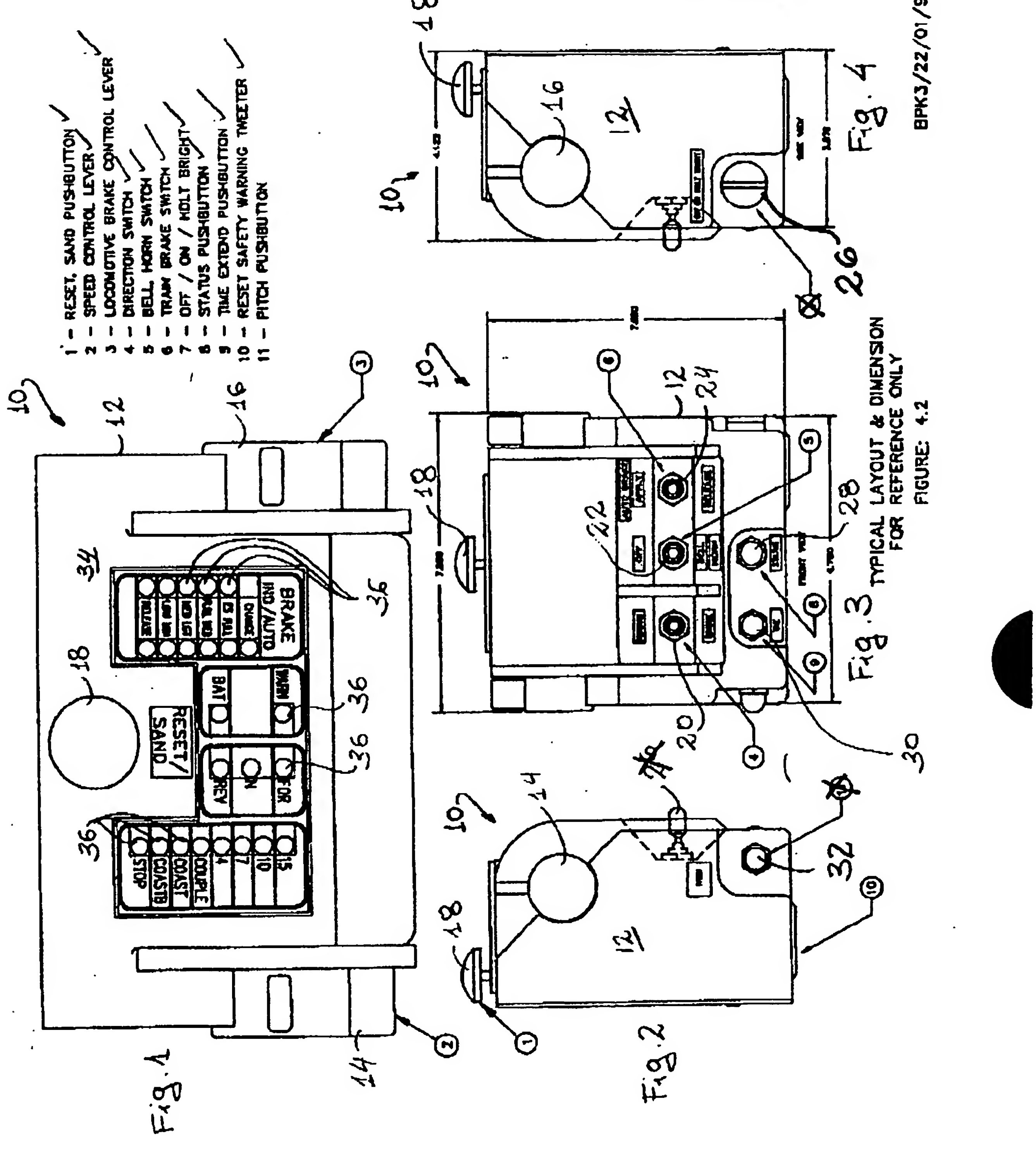

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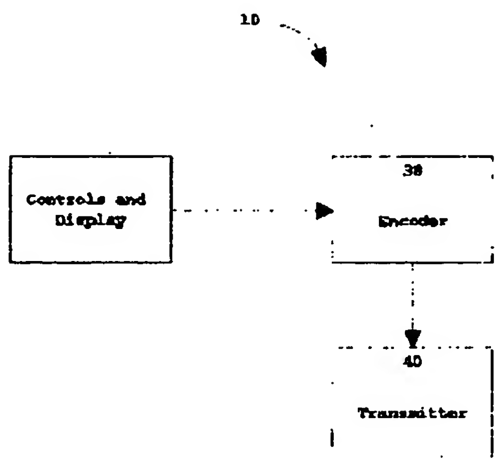


Fig. 4

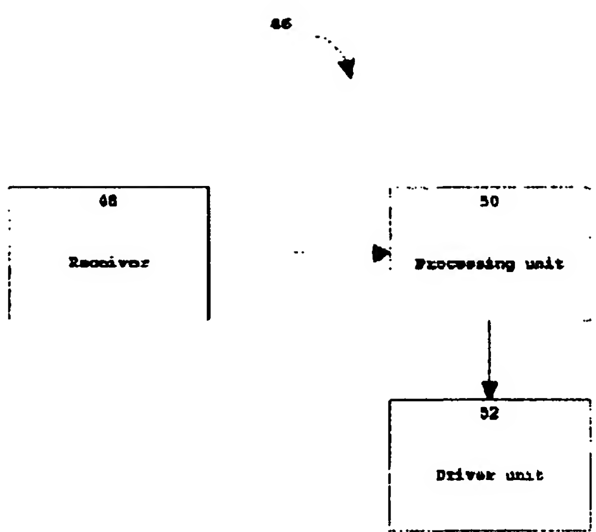


Fig. 6

2120454

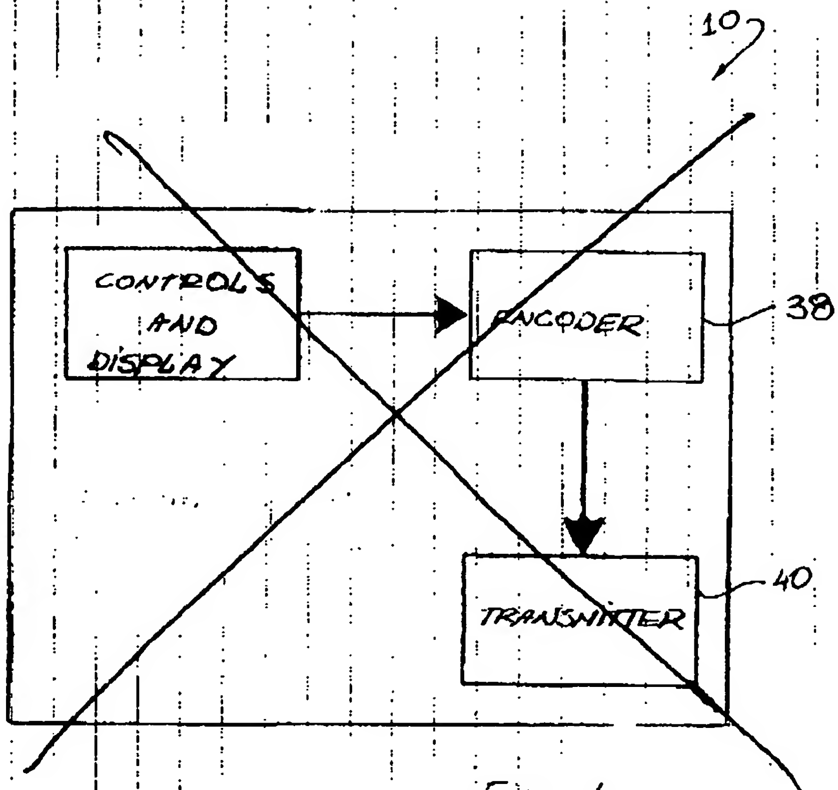


Fig. 4

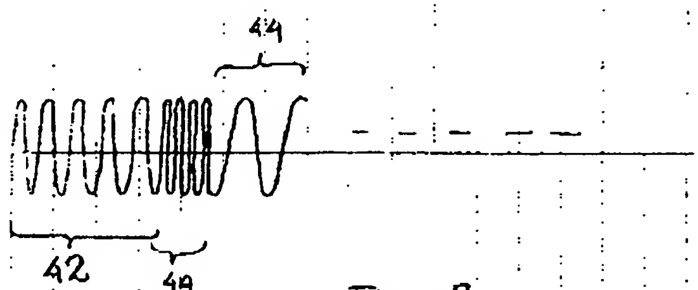


Fig. 5

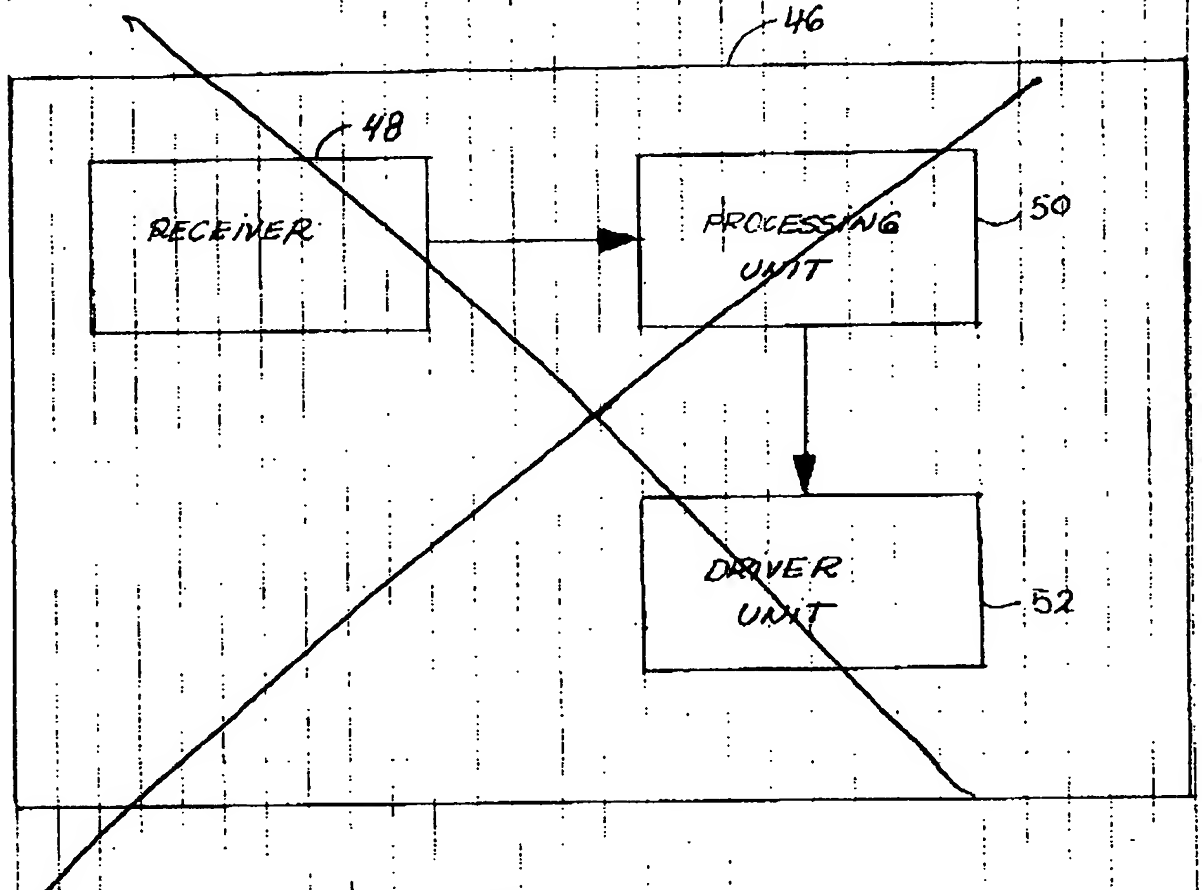

46
48
RECEIVER
PROCESSING UNIT
50
DRIVER UNIT
52

Fig. 6

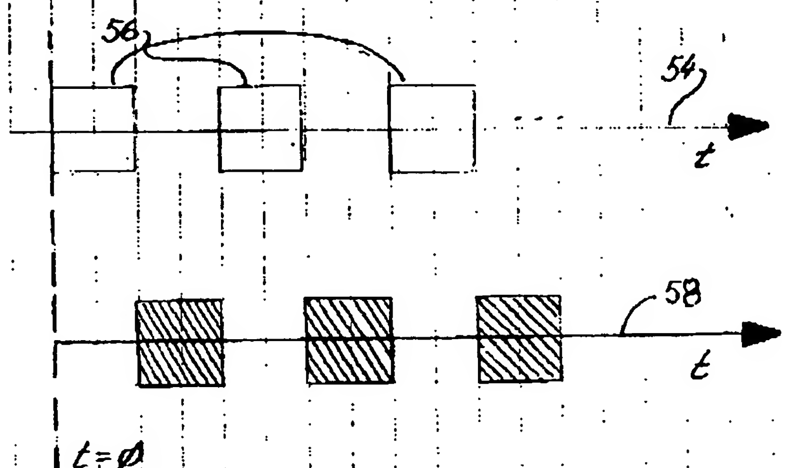

56
54
t
58
t
t=ø

Fig. 7

2120454

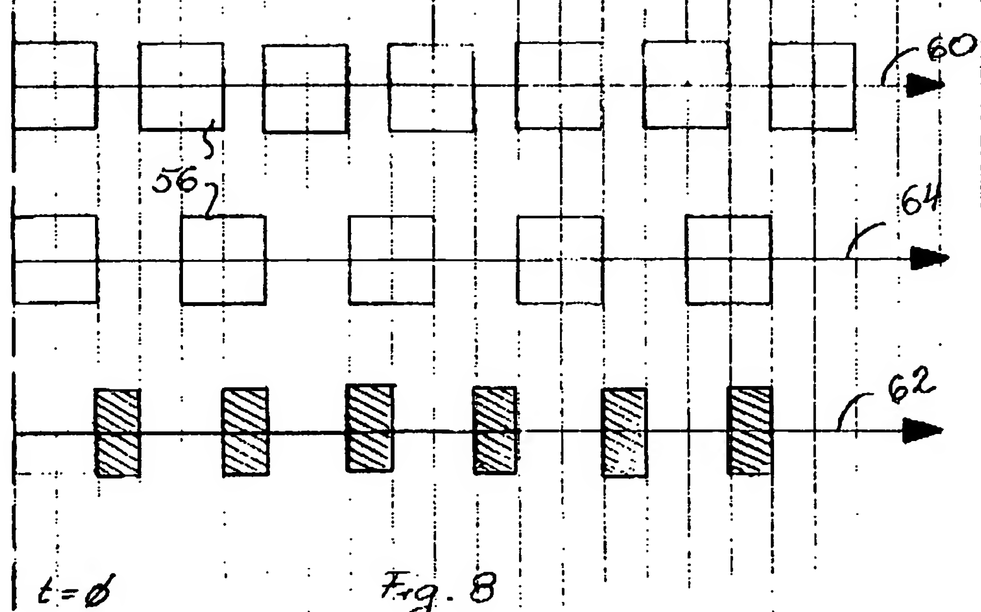


Fig. 8

2120454

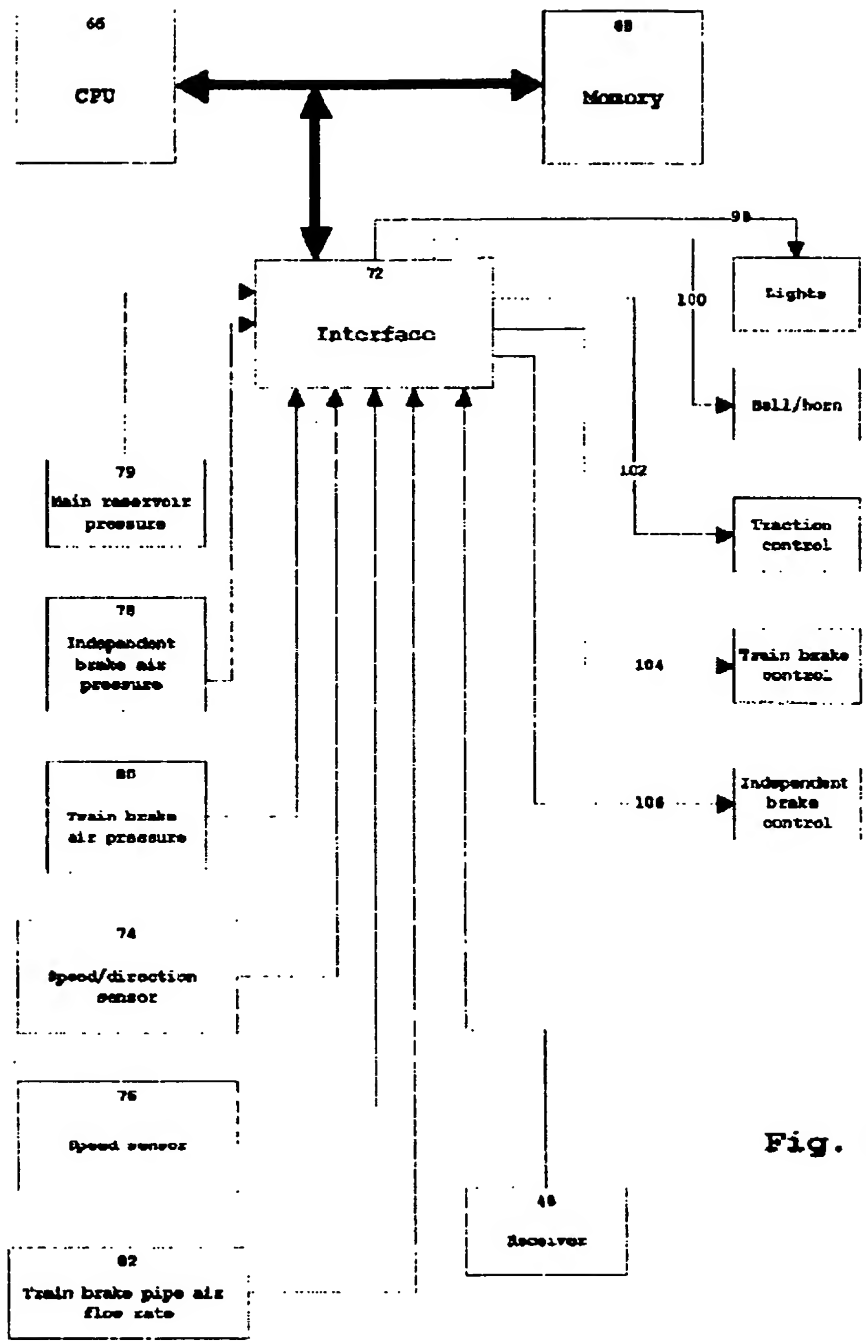


Fig. 9

2120454

FIG.3

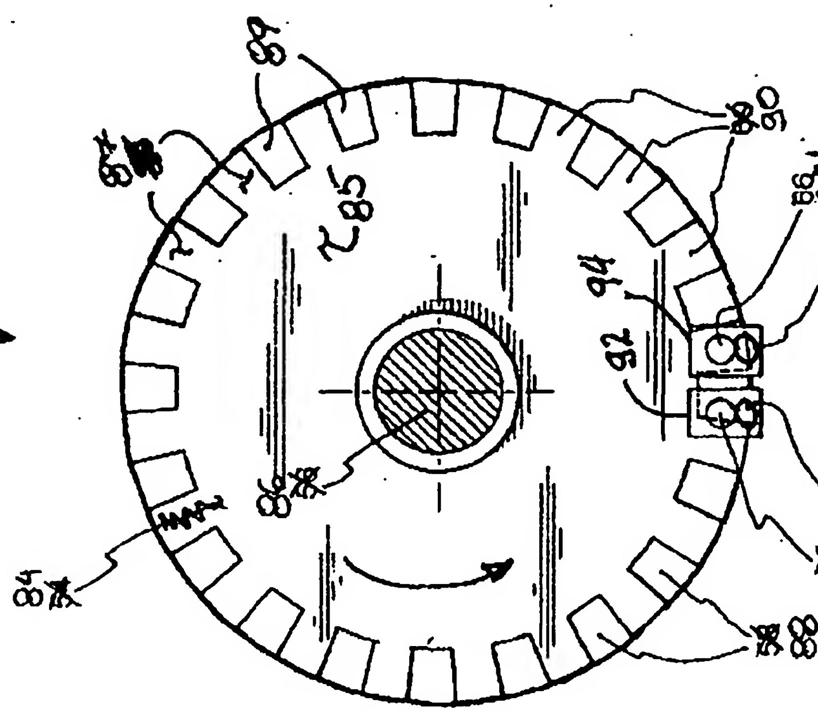


FIG.~~4~~ 10

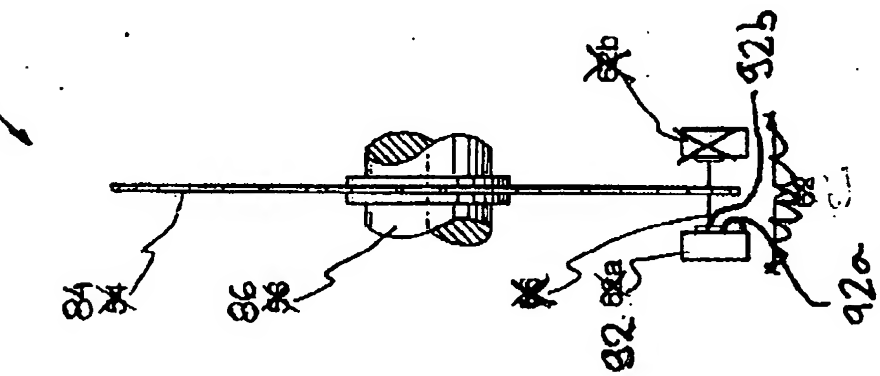


FIG.~~5~~ 11

ENV.PAR:S&B/F&Co 4 P.V.M. : 3-31-94 : 18:06 : FETHERSTONHAUGH- 510 BURRARD VAN:# 8/17

2120454

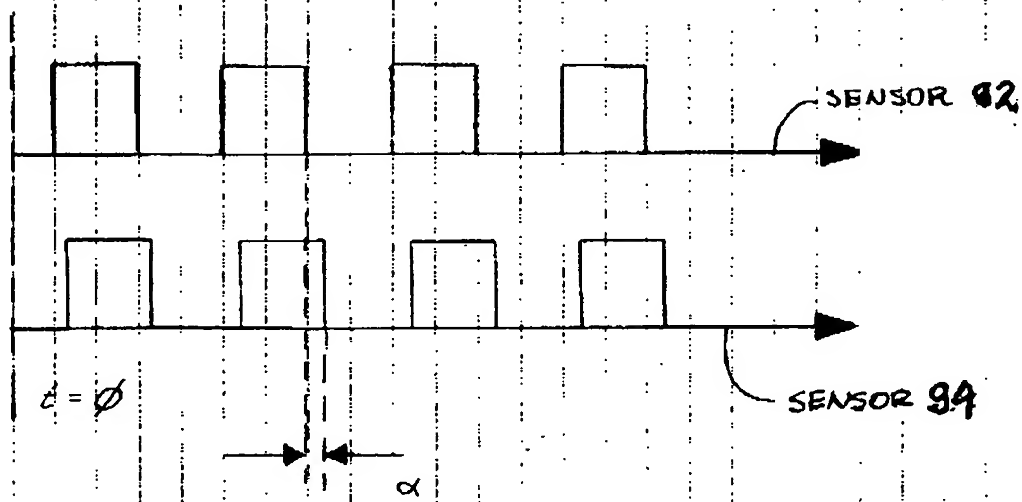


Fig. 12

2120454

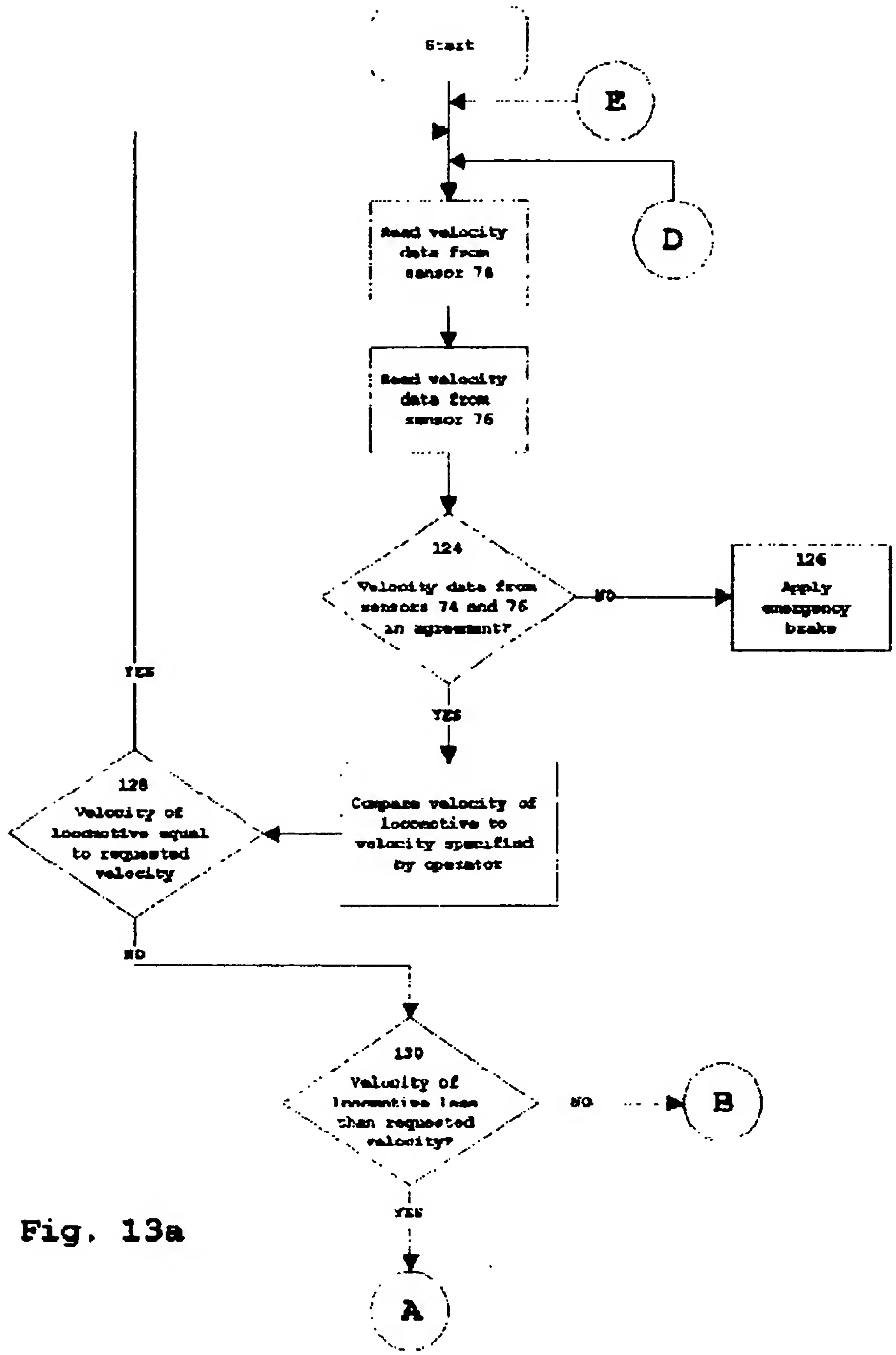


Fig. 13a

2120454

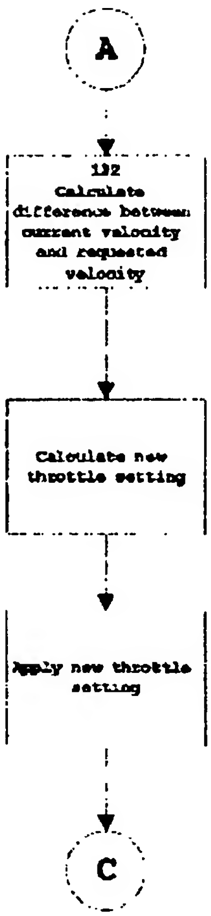


Fig. 13b

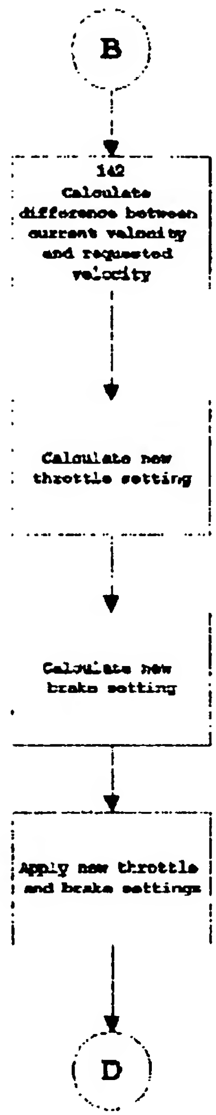


Fig. 13c

2120454

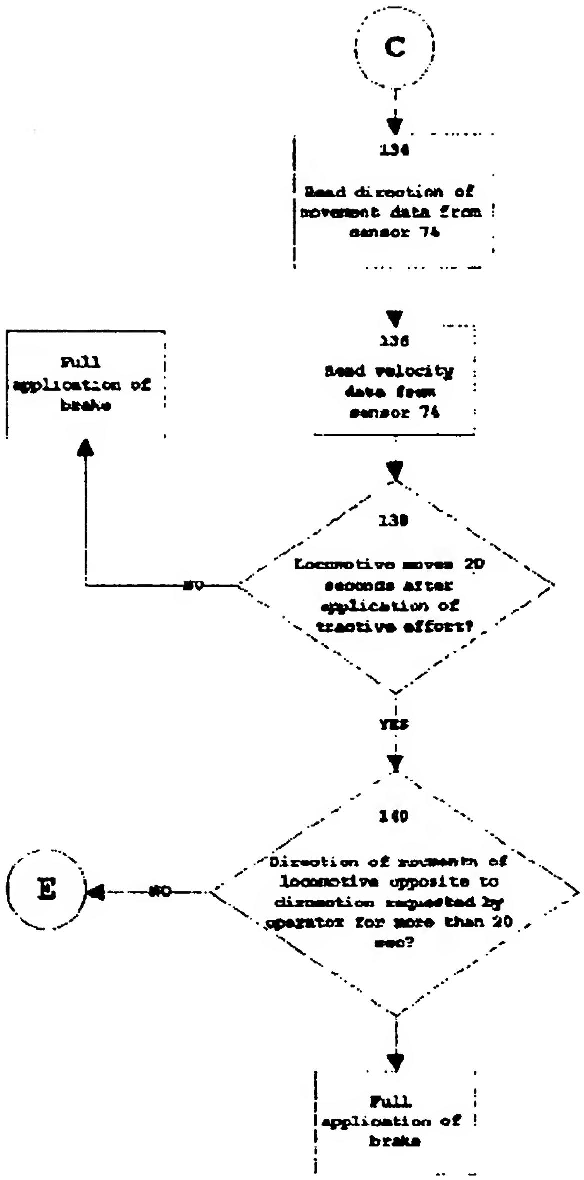


Fig. 13d

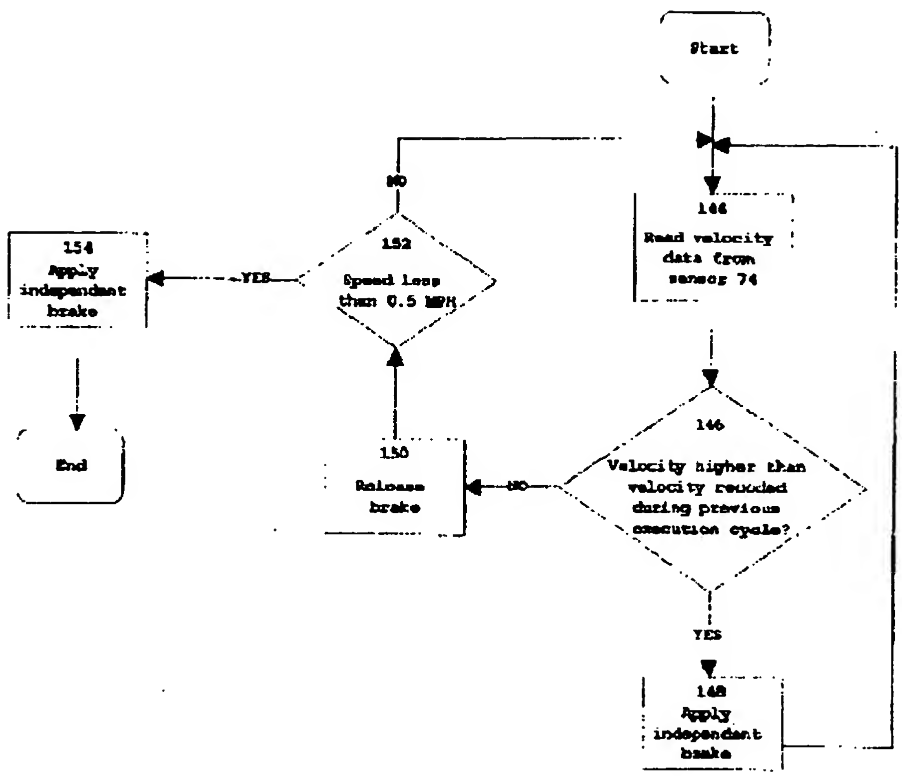

Start
144
Read velocity data from sensor 74
146
Velocity higher than velocity recorded during previous execution cycle?
YES
148
Apply independant brake
NO
150
Release brake
152
Speed less than 0.5 MPH
NO
YES
154
Apply independant brake
End

Fig. 14a

2120454

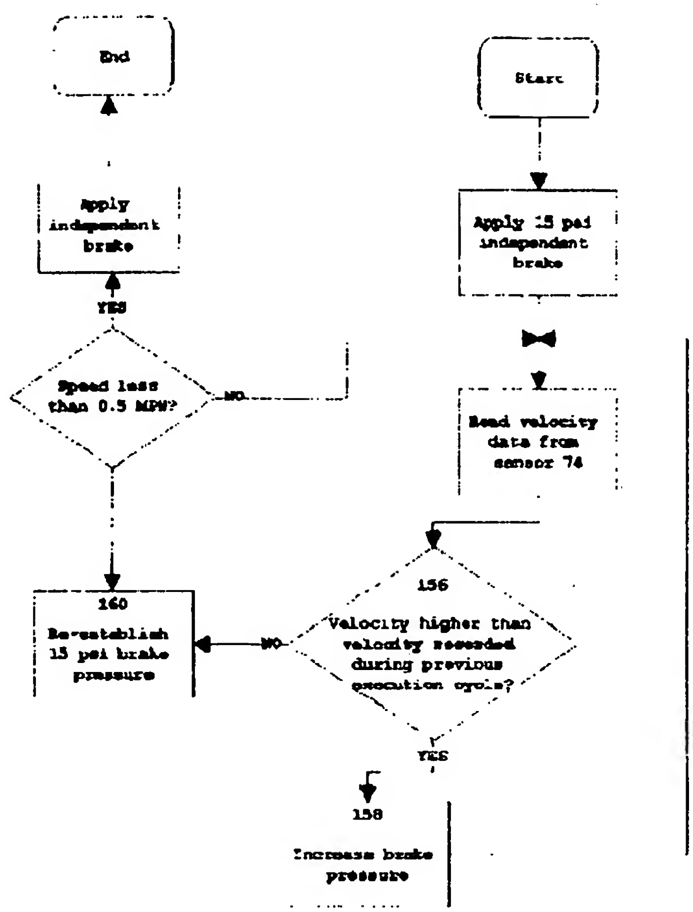


Fig 14b

2120454

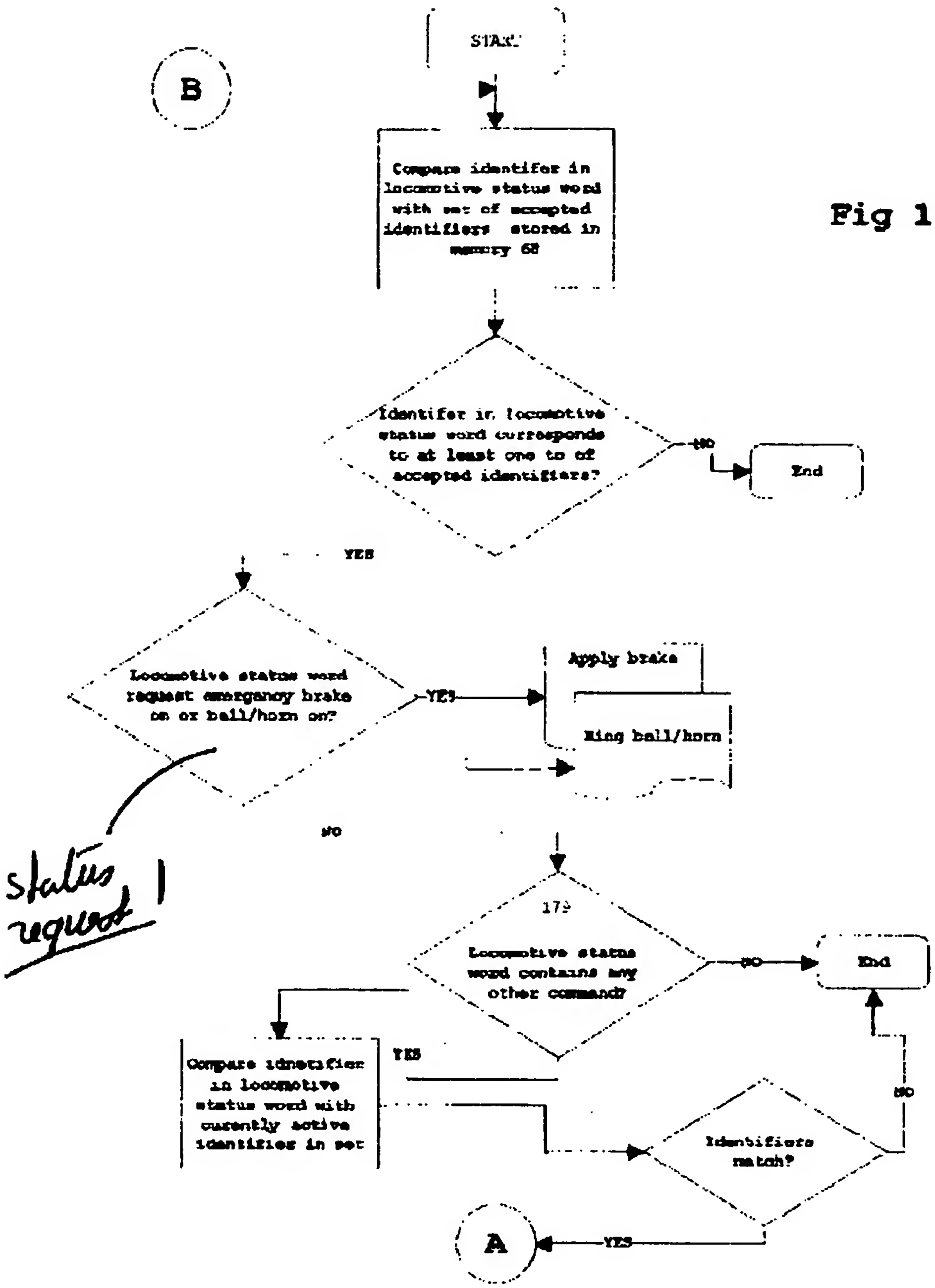
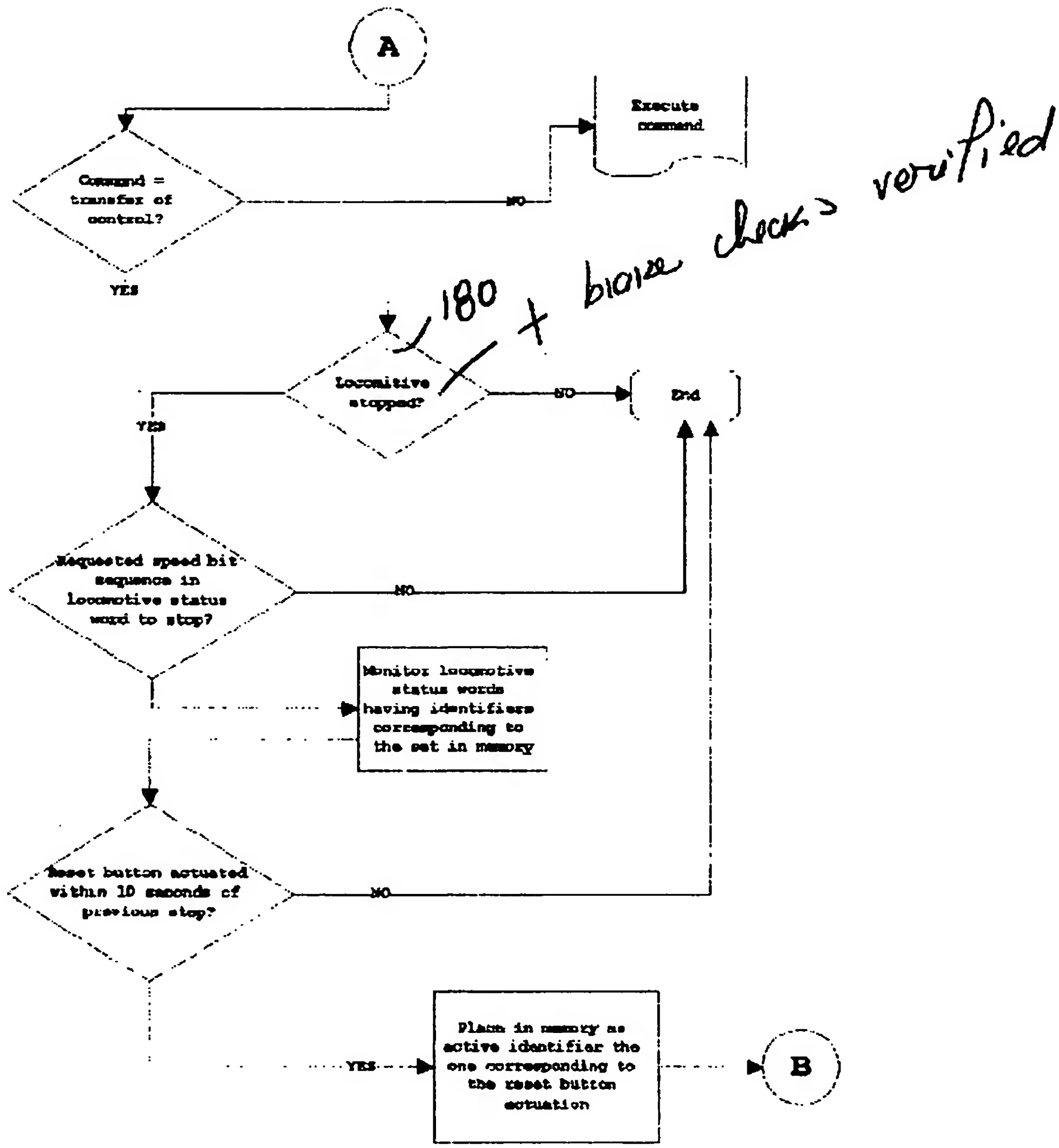


Fig 15a

Fig. 15b


A
Command = transfer of control?
NO
Execute command
YES
Locomitive stopped?
NO
End
YES
Requested speed bit sequence in locomotive status word to stop?
NO
Monitor locomotive status words having identifiers corresponding to the set in memory
Reset button actuated within 10 seconds of previous stop?
NO
YES
Place in memory as active identifier the one corresponding to the reset button actuation
B
180 + biaise checks verified

2120454

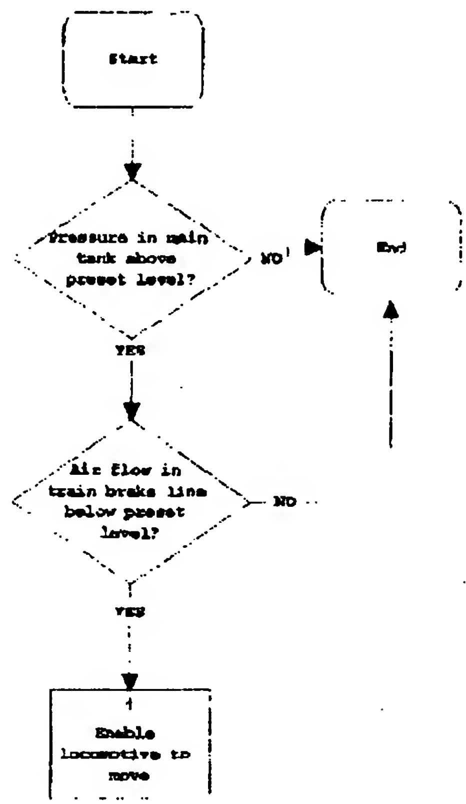


Fig. 16